Nuclear Energy University Programs

Used Fuel Disposition

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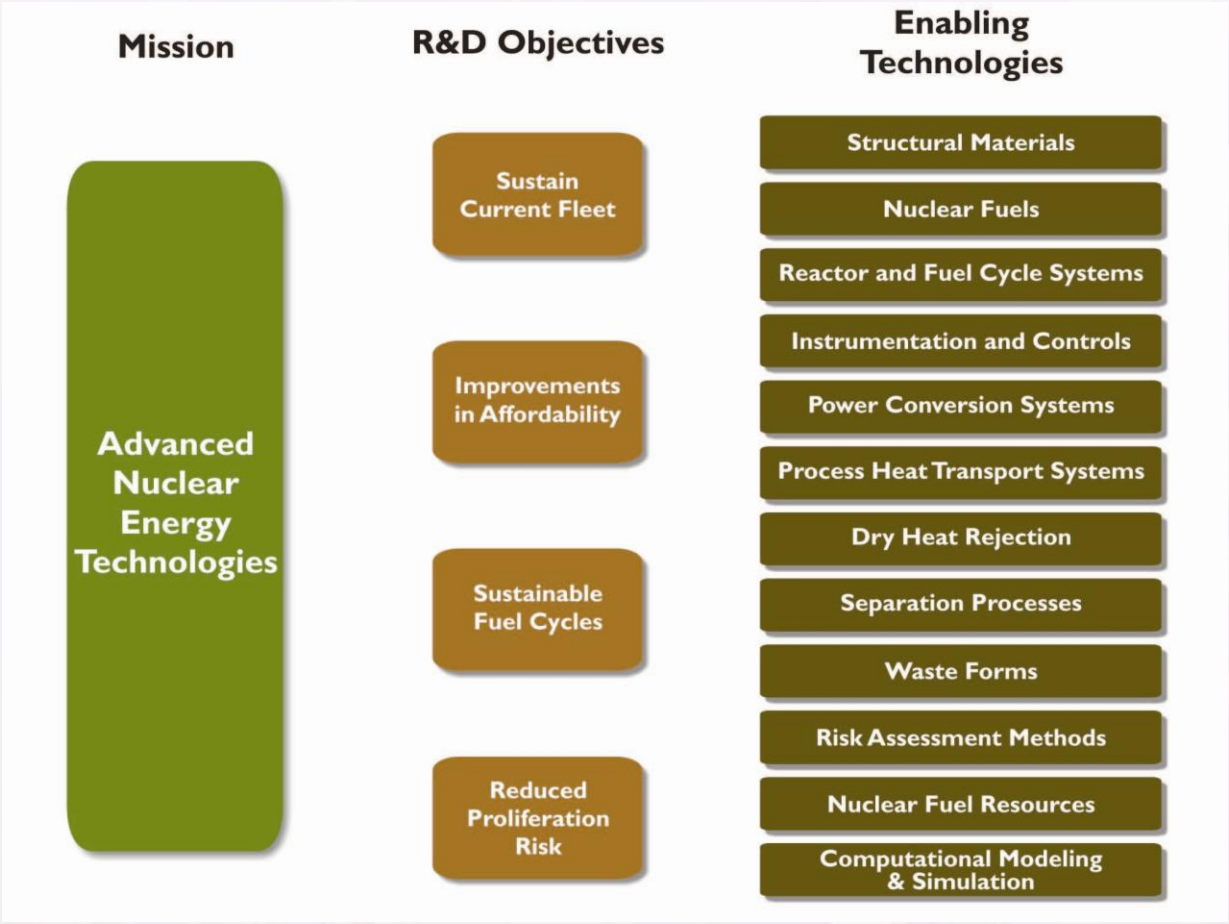
Used Fuel Disposition Overview

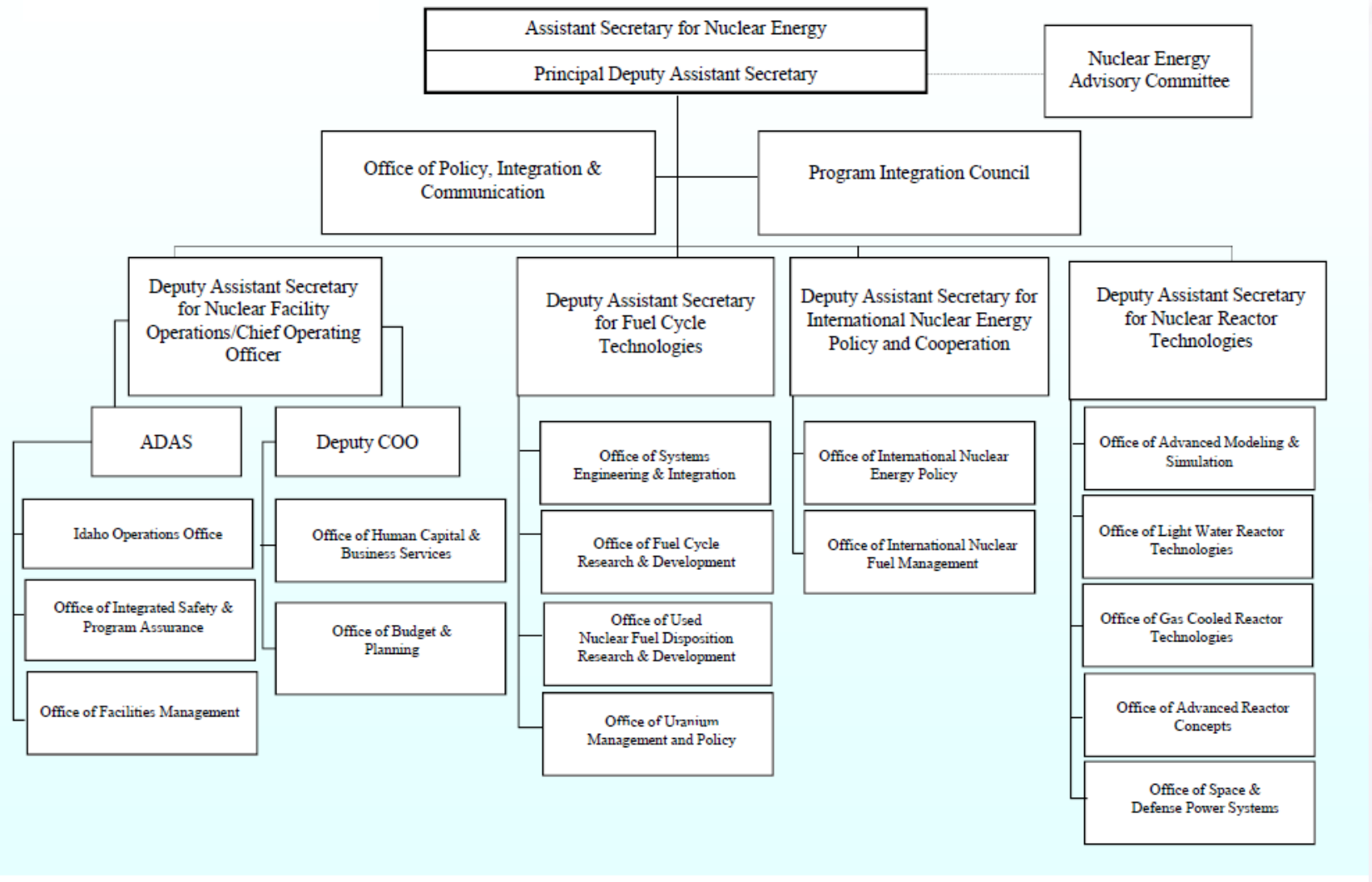
- DOE Office of Nuclear Energy Mission
  - The primary mission of the Office of Nuclear Energy is to advance nuclear power as a resource capable of meeting the Nation's energy, environmental, and national security needs by resolving technical, cost, safety, proliferation resistance, and security barriers through research, development, and demonstration as appropriate.
- Used Fuel Disposition Mission
  - The mission of the Used Fuel Disposition Campaign is to identify alternatives and conduct scientific research and technology development to enable storage, transportation and disposal of used nuclear fuel and wastes generated by existing and future nuclear fuel cycles.

DOE-NE Mission and Objectives

(from the 2010 DOE-NE Roadmap Report to Congress)



DOE-NE Organization



UFD Campaign 2009-Present

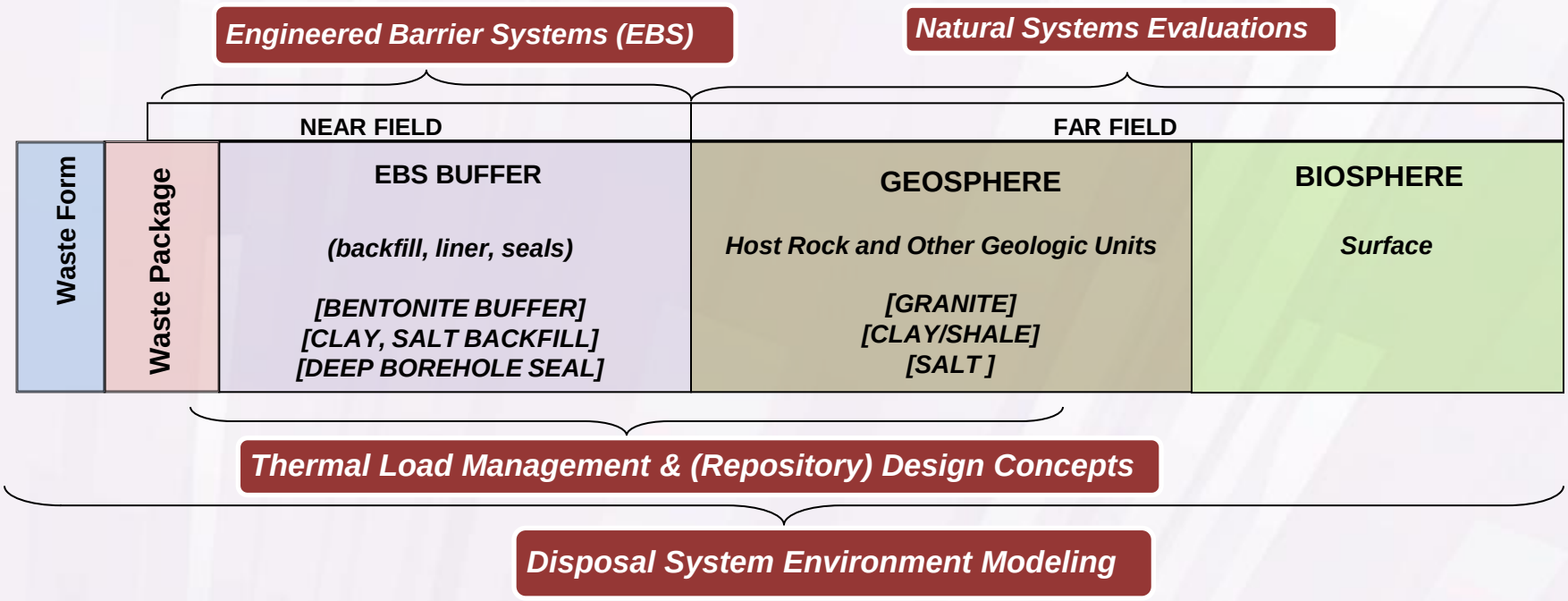
- History of the campaign
  - FY09: Planning meeting at Argonne National Laboratory, June 2009
  - FY10: Relatively small program
    - Disposal R&D, modest level of effort on Storage R&D, no Transportation R&D
  - FY11: Substantial increase in scope with termination of DOE Office of Radioactive Waste Management
    - Nine national laboratories participating in UFD
    - Significant R&D program in Storage, including Transportation
    - Incorporation of RW science programs into Disposal R&D
  - FY12:
    - Uncertainties remain regarding national policy, Yucca Mountain litigation and licensing, and budget

FY12 UFD Campaign Structure

Management Group	R&D Activities
Crosscut activities	
	Campaign Management and Integration
	Perspectives on Nuclear Waste Management
	International
	UFD Science Competition
Disposal Research	
	Thermal Load Management and Design Concepts
	Generic EBS Evaluation
	Generic Natural Systems Evaluation
	Generic Disposal System-Level Modeling
	Features, Events, and Processes
	Inventory
	LLW Disposition
Storage and Transportation Research	
	Test and Evaluation Capability Development
	Storage R&D Investigations
	Transportation
	Security
	Engineering Analysis
	Engineered Materials -- Experimental

Used Fuel Disposition Campaign R&D Participants

UFD Disposal Research Activities

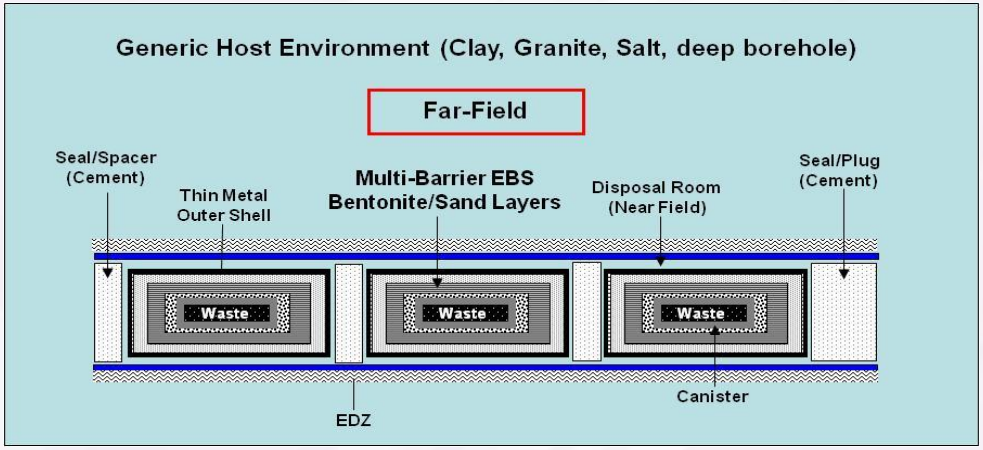


SUPPORT, ANALYSIS & EXPERIMENTAL

Engineered Materials Performance	*(corrosion, degradation studies)*
Nuclear Waste Management Perspectives	*(regulatory, systems integration, social issues)*
Features, Events & Processes	*(how R&D is organized and prioritized)*
Low Level Waste Disposition Issues	*(part of total nuclear waste consideration)*
Inventory Projections	*(LLW/HLW, used fuel, open → closed fuel cycles)*
Salt Disposal Investigations	*(proposed specific geologic media investigation)*

Engineered Barrier Systems R&D

EBS and materials evaluation for multiple disposal environments (clay/shale, granite, salt, deep-borehole).



FY11 ACCOMPLISHMENTS:

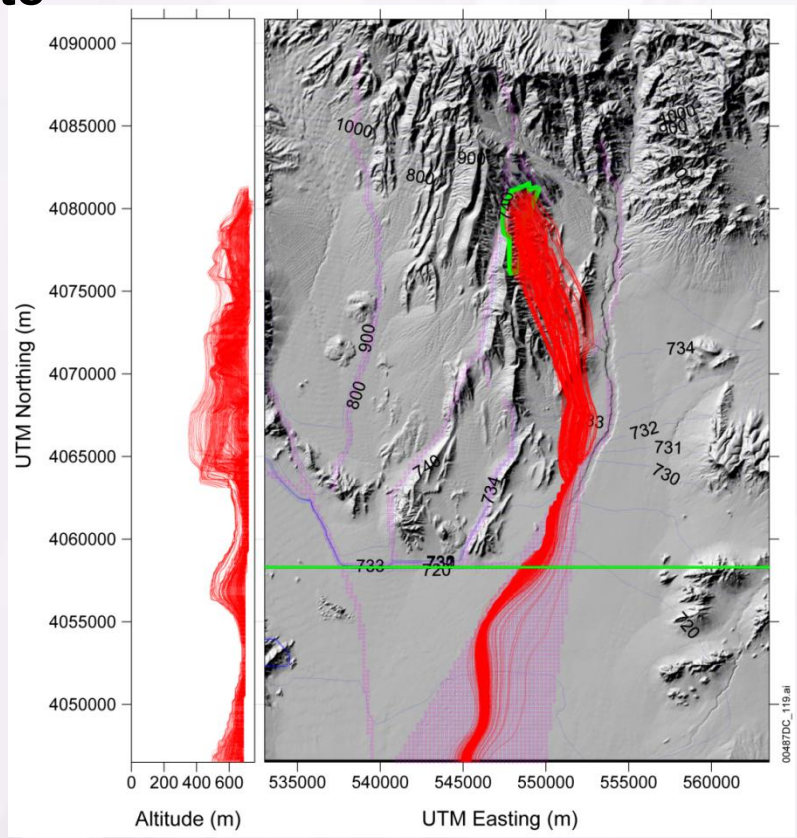
- Performed evaluation of EBS configurations and material properties: backfill and sealing material (clay and cement)
- Evaluated clay / metal interactions at elevated temperatures and pressures: literature review, clay phase characterization, and experiments
- Expanded and validated THM constitutive and reactive diffusive transport modeling in bentonite
- Disposal System Evaluation Framework (DSEF): developed EBS heat transport model and catalog of thermal properties for various repository environments

Natural Systems Evaluation R&D

Evaluation of key natural system attributes of multiple disposal system concepts to evaluate impacts on waste immobilization and isolation.

FY11 ACCOMPLISHMENTS:

- Modeling & experimental approaches formulated .
- Progress made to bridge key technical gaps identified in UFD R&D roadmap including:
  - direct disposal of e-chem salt in a salt repository,
  - radionuclide interaction with geo-materials,
  - constitutive relationships for near-field process coupling
  - radionuclide transport in the far field.



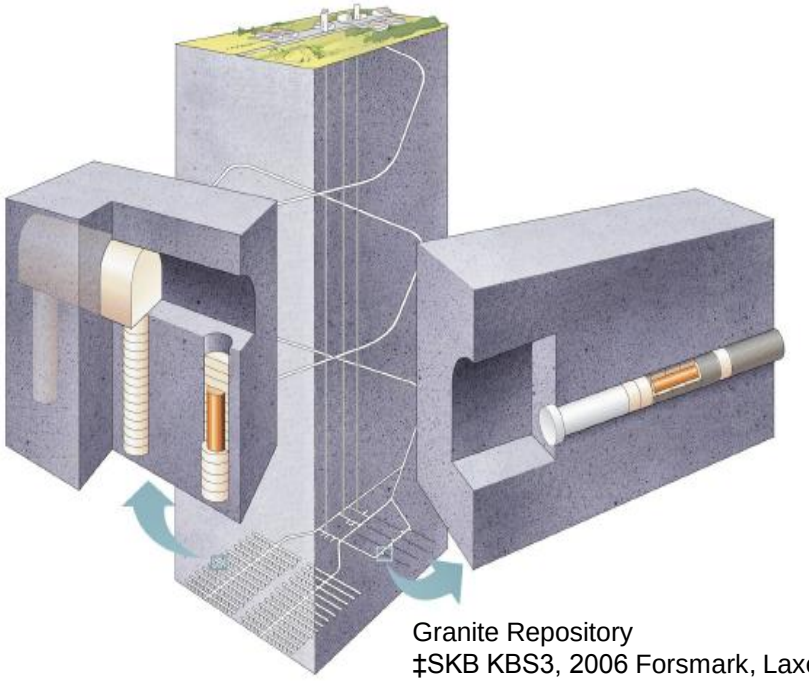
Simulated Flow Paths, Saturated Zone FEHM. Yucca Mountain Project

Thermal Load Management & Design Concepts R&D

Thermal modeling and testing to evaluate thermal loading options for multiple disposal concepts and alternative waste forms.

FY11 ACCOMPLISHMENTS:

- Began the development of representative design concepts for repositories in clay/shale, granite, salt, and deep borehole settings.
- Developed waste streams for thermal analysis in FY11
- Developed plans for a lab experiment representing radionuclide transport in the near field
- Initiated software development to couple TOUGHREACT-FLAC3D for full THMC capability



Granite Repository
‡SKB KBS3, 2006 Forsmark, Laxemar

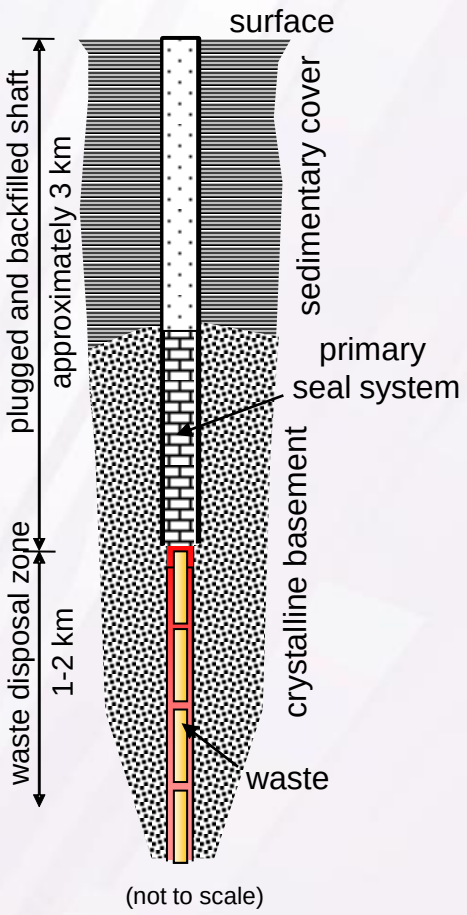
Disposal System Environment Modeling R&D

Maintain and update models to evaluate performance of multiple generic disposal systems. Includes:

1. **Enhancing system models (granite, salt, clay/shale, and deep boreholes);**
2. **Developing models for conceptual engineered barriers; and**
3. **Initiation of models of other disposal as appropriate.**

FY11 ACCOMPLISHMENTS:

- Implemented configuration management for the generic performance assessment (PA) models
- Documented technical basis for treatment of Features, Events, and Processes for each generic PA model
- Developed preliminary (first-order), simple geometry, generic PA models for repositories in clay/shale, granite, salt, and deep borehole settings.
  - ➢ Isothermal models except for deep borehole



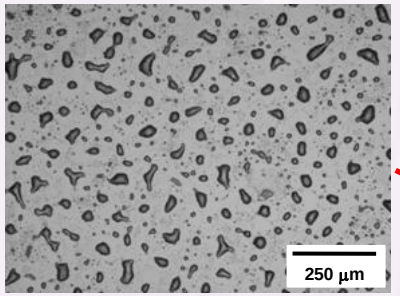
Source: modified from Brady et al., 2009, Deep Borehole Disposal of High-Level Radioactive Waste, SAND2009-4401

Engineered Materials Performance R&D

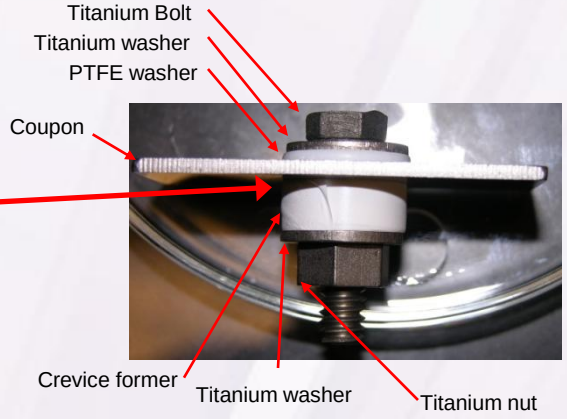
Experiments and model development for long-term performance of engineered materials in repository environments. Provides data for assessing metal corrosion in a range of environmental conditions.

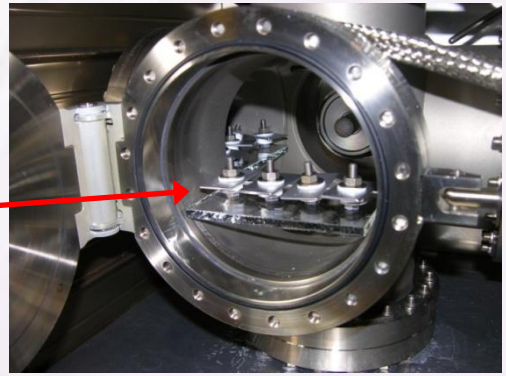
FY11 ACCOMPLISHMENTS:

- Ongoing experiments (YMP initiated, continuing):
  - Immersion: Sampled after 9 months of exposure (12/10). Analysis of samples underway
  - Deliquescence: Corrosion initiation experiments with 2-,3-, and 4-salt assemblages completed
  - Dependence of extent of corrosion on quantity of salt present is now being investigated
- Literature survey/gap analysis for material performance in repository environments has been initiated



Salt mixture on an Alloy 22 Coupon

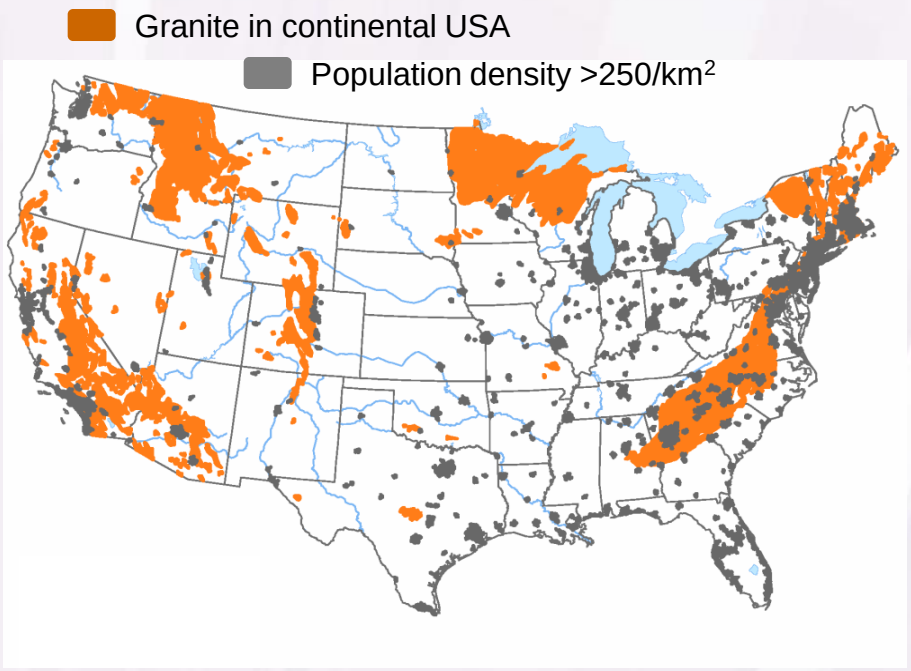



T, RH-Controlled Environmental Chamber

Nuclear Waste Management Perspectives

Social and political developments have a potential to modify options for nuclear waste management. This activity includes three primary tasks:

1. **Evaluate potential sociopolitical impacts on UFD R&D activities;**
2. **Review relevant social science issues; and**
3. **Evaluate interface options among storage, transportation and disposal**

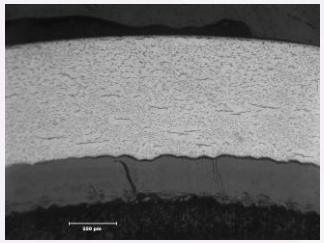


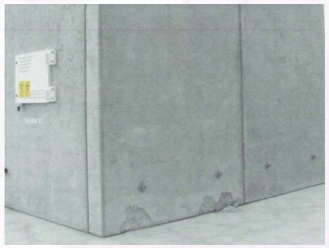
FY11 ACCOMPLISHMENTS:

- Completed Level 2 report on basis of decision for UFD to focus on salt, clay/shale, and granite for mined and deep borehole disposal
- Completed contract with Center for Applied Social Research at U of OK and nearing completion of survey questions related to nuclear waste disposal

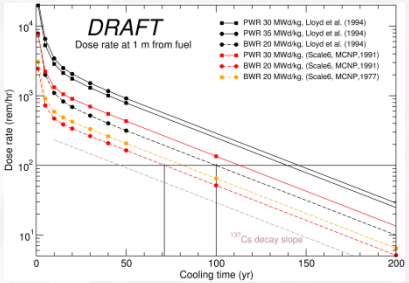
Storage and Transportation Work Packages Overview

- Storage R&D Investigations
  - Data gap analyses
  - Plan to address gaps
  - Development of technical basis

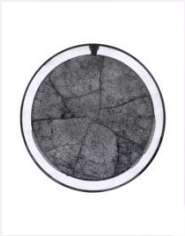


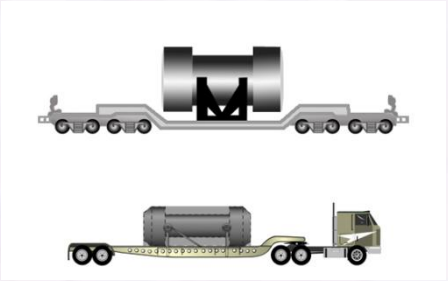


- Security
  - Regulatory assessment
  - Identify issues for long-term storage and subsequent transportation
  - Evaluate methods for security assessment over long-term storage



- Transportation
  - High burnup fuels
  - Transportation of all fuels after storage



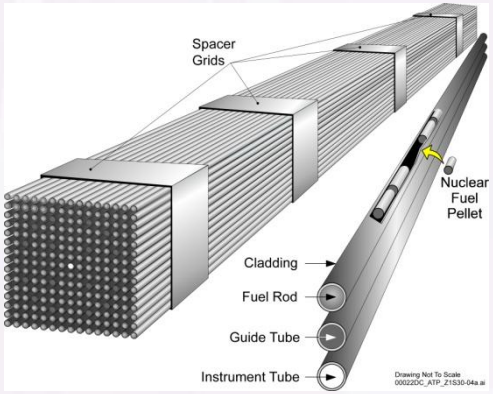


- Conceptual Evaluation
  - Evaluate scenarios for accomplishing development of technical basis
  - Develop a systems framework for decision-making

Storage System Components

I. Fuel

I. Fuel/Pellet
II. Cladding
III. Assembly hardware

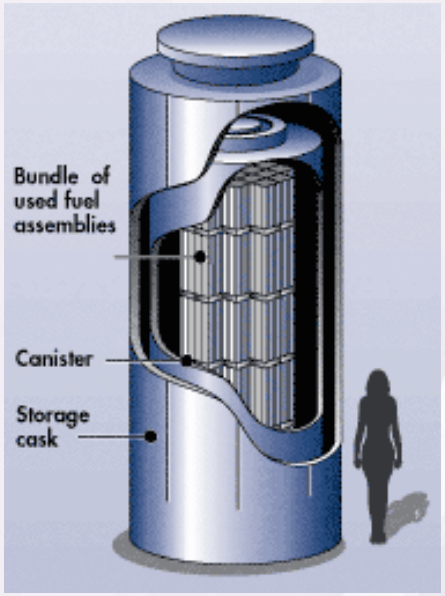


III. ISFSI

I. Pad
II. Rebar
III. Physical Protection

II. Cask

I. Internals (baskets, neutron poisons)
II. Container (canister, welds, seals, bolts)
III. Overpack/Storage module

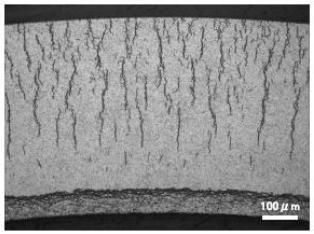


IV. Monitoring Systems

I. Remote inspection
II. In-package sensors
III. Security

Preliminary List of High and Medium Priority R&D Needs for Storage

System	Issue	Importance of R&D
Cladding	Annealing of Radiation Effects	Medium
	Oxidation	Medium
	H_2 effects: Embrittlement, Delayed Hydride Cracking	High
	Creep	Medium
Container (Welds, Bolts, Metal Seals)	Humid Oxidation	High
	Marine Environment	High
	Wet Corrosion: General, Pitting, SCC, Crevice, Galvanic	High
	Temperature Fluctuations Relax Metal Seals and Bolts	Medium
Monitoring Systems	Develop New Performance Confirmation Monitoring Systems	Medium



Radial hydrides in fuel clad

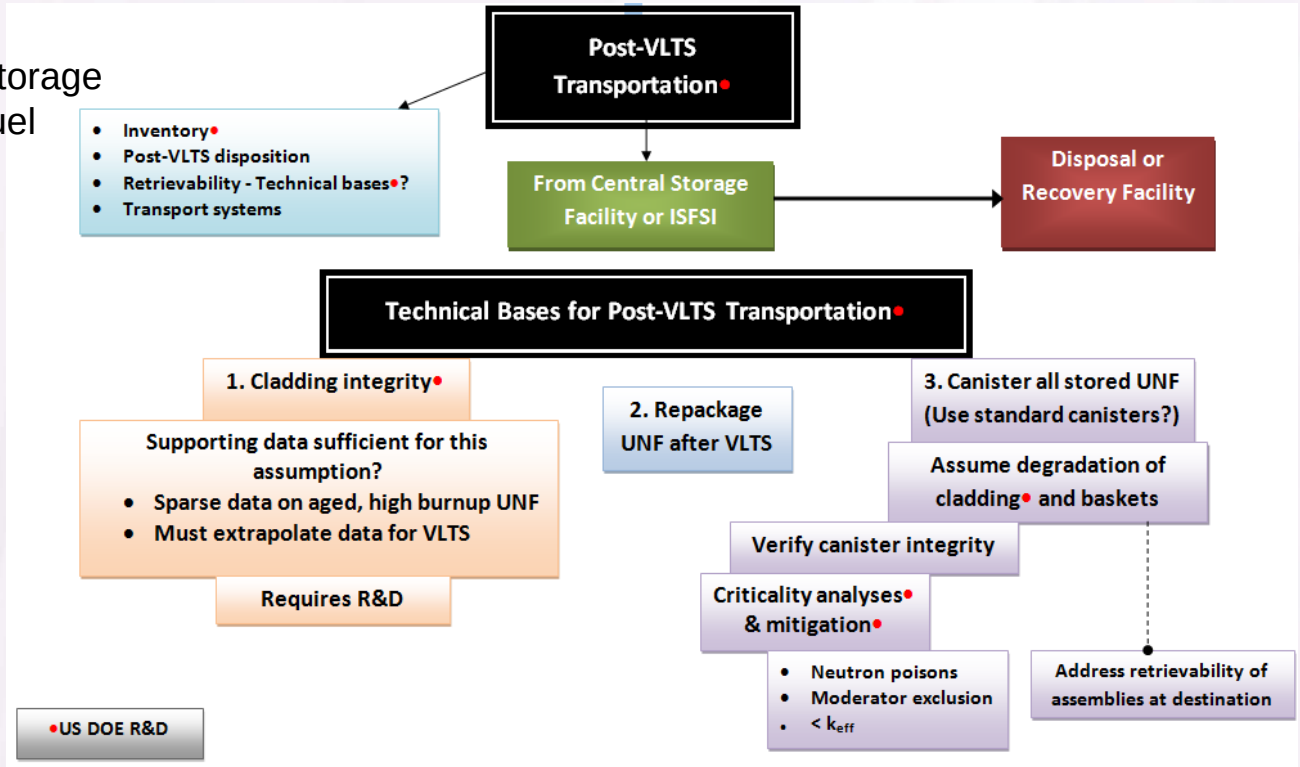
Bolt corrosion in cask bottom cover plate

Transportation Objectives and Activities

Objectives:

Develop the technical basis:

- for transport after long term storage
- for transport of high burnup fuel
- for transportability of dual-purpose casks



Activities Include:

- Gap analysis
- Retrievability of fuel after storage
- Evaluation of fuel loading during transport
- Criticality investigations
- Dual-purpose cask assessment
- Transport to centralized storage: dry fuel transfer
- ASME NUPACK
- IAEA WG on Dual Purpose Casks

Questions?